SEMESTER I

Discipline : CIVIL ENGINEERING
Stream : CE1

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE100	PROBABILITY AND STATISTICS	DISCIPLINE CORE	3	0	0	3

Preamble: The objective of this course is to expose the students to the fundamental concepts of probability and statistics. The course aims to equip the students to find solutions for many real-world civil engineering problems and to understand basic data analysis tools by applying the principles of statistics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	To create an awareness of the concepts of statistics and probability distributions
CO 2	To formulate and test hypotheses for civil engineering problems
CO 3	To apply statistical data analysis tools such as ANOVA and experimental designs
CO 4	To build regression models for civil engineering applications and to identify the principal components
CO5	To apply the concepts of data analysis for a time series

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2		3			2
CO 2	3	2	2	3	3		2
CO 3	3	2	2	3	3		2
CO 4	3	2	2	3	3		2
CO5							

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	25
Evaluate	5
Create	5

Mark distribution

Total Marks	CIA	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Micro project/Course based project	:	20 marks
Course based task/Seminar/Quiz	:	10 marks
Test paper, 1 no.	:	10 marks

The project shall be done individually. Group projects are not permitted. The project may include the implementation of theoretical computation using software packages.
The test papers hall include a minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Syllabus

Module 1- Introduction to probability distributions

Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence. Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.

Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.

Module 2- Statistical Inference

Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:-Confidence interval for mean and variance.-Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.-Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence

Module 3- Analysis of variance

Analysis of variance. Completely randomized designs and randomized block designs.- Latin square designs -Factorial experiments: Two-factor experiments (overview only)

Module 4- Correlation and regression models

Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient- Multiple linear regression, normal equations -Principal components (brief overview only)

Module 5-Time Series Models

Components of time series. Identifying linear trend: semi averages method and least squares method. Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient. Forecasting, measuring forecasting accuracy

Course Plan

No	Topic	No. of Lectures
1	**Introduction to probability distributions**	
1.1	Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence.	1
1.2	Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.	2
1.3	Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.	5
2	**Statistical Inference**	
2.1	Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:- Confidence interval for mean and variance.	2
2.2	Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.	2

2.3	Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence	4
3	**Analysis of variance**	
3.1	Analysis of variance. Completely randomized designs and randomized block designs.	4
3.2	Latin square designs	2
3.3	Factorial experiments: Two-factor experiments (overview only)	2
4	**Correlation and regression models**	
4.1	Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient	4
4.2	Multiple linear regression, normal equations	2
4.3	Principal components (brief overview only)	2
5	**Time Series Models**	
5.1	Components of time series. Identifying linear trend: semi averages method and least squares method.	2
5.2	Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient.	3
5.3	Forecasting, measuring forecasting accuracy	3
	Total hours	40

Reference Books

1. Gupta. S. C. and Kapoor. V. K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2020
2. Benjamin, Jack.R and Comell.C, Allin, Probability, Statistics and Decision for Civil Engineers, Mc- McGraw-Hill.
3. Johnson RA , Miller I, Freund J. Miller and Freund's Probability and Statistics for Engineers (9th edition) Pearson. 2018.
4. Response Surface Methodology: Process and Product Optimization Using Designed Experiments, 4th EditionRaymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook ISBN: 978-1-118-91601-8 February 2016.
5. Introduction to Time Series Analysis and Forecasting Second Edition, DOUGLAS C. MONTGOMERY, CHERYL L. JENNINGS, MURAT KULAHCI, John Wiley & Sons, 2015.
6. Papoulis A, Pillai SU Probability, Random Variables and Stochastic Processes McGraw Hill 2022
7. Schiller J, Srinivasan RA, Spiegal M Schaum's Outline of Probability and Statistics, 2012 McGraw Hill
8. Ross S Introduction to Probability and Statistics for Engineers and Scientists Elsevier 6th Edition 2021

Model Question Paper

XXXX PROBABILITY AND STATISTICS

Time: 3 Hrs Max. Marks:60

PART A

(Answer all Questions: Each question carries 5 marks)

1. Explain the concept of mean, median and mode, and its applicability in various contexts with suitable examples.
2. Explain Type I and Type II errors with example.
3. What are the assumptions involved in Analysis of Variance (ANOVA)?
4. Obtain Karl Pearson's correlation coefficient for Stress and Performance.

Observation no.	1	2	3	4	5
Performance	75	80	85	90	95
Stress	80	75	80	60	55

5. Explain briefly the components of time series.

PART B

(Answer any five questions: Each carry 7 marks)

6. The number of products sold by a shop keeper follows Poisson distribution, with a mean of 2 per week. (i) Find the Probability that in the next 4 weeks the shop keeper sells exactly 3 products. (ii) The shop keeper monitors sales in periods of 5 weeks. Find the probability that in the next 15 of these 5-week period, there are exactly 10 periods in which more than 5 products are sold.
7. After conducting series test on ProbabilityandStatistics the following scores were obtained for Batch A and Batch B. Conduct a hypothesis testing for checking the equality of variance in scores of two batchesat a significant level corresponding to a β error probability of 0.9.

A	35	40	42	30	12	50	45	28	26	30
B	20	24	28	26	18	50	50	48	48	09

8. In order to evaluate safety performance of employees across 3 departments, 5 employees across each department were randomly monitored and their safety behaviour on a hundred scale is given below. Do the departments differ in their safety behaviour?

Department	1	2	3	4	5
A1	68	73	75	65	78
A2	85	85	78	86	79
A3	73	77	72	70	76

9. Develop a Regression Equation between A and Busing Method of Least Square. Consider B as the dependent variable. Explain the significance of estimated slope.

Observation no.	1	2	3	4	5
A	75	80	85	90	95
B	80	75	80	60	55

10. Foodgrain production (in lakh tones) is given below. Find the Trend by using 3-yearly and 4-yearly movingaverage method, tabulate the trend values and predict the production for the year 2022.

Years	Production
2008	40
2009	60
2010	45
2011	85
2012	130
2013	135
2014	150
2015	120
2016	200

11. An evaluation of teaching methods shows the following outcomes.

Method of Teaching	No of students	Average marks obtained	Population Standard Deviation
Chalk and Talk Method	32	70	5
PPT and Talk Method	29	65	8

Conduct hypothesis testing for the mean difference of the teaching methods at a significant level corresponding to a Type I error probability of 0.01.

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CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE001	ADVANCED DESIGN OF STRUCTURES	PROGRAM CORE 1	3	0	0	3

Preamble: The course covers advanced topics related to the behaviour and design of reinforced concrete and steel structures. The advanced topics include yield line method of analysis, grid floor and flat slab design, beams, and foundation design. The course also covers advanced design concepts for specific structural steel applications.

Course Outcomes: After the completion of the course on Advanced Design of Structures the student will be able to.

CO 1	Analyse and design slabs using yield line theory
CO 2	Apply IS code provisions for the analysis, design and detailing of flat slabs
CO 3	Design of continuous beams and pile foundation
CO 4	Design of beam column connections in steel buildings
CO 5	Design large span roofing systems for industrial structures

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			2	1			
CO 2	1		3	2	1		
CO 3			3	2	1		
CO 4			3	2	1		
CO 5			3	2	1		

(1- Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	
Understand	20
Apply	30
Analyse	10
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221TCE001

ADVANCED DESIGN OF STRUCTURES

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Explain the characteristic features of yield line.
2. Discuss the following: i) Applications of flat slab ii) Components of flat slab
3. Discuss the design procedure of a pile cap.
4. Explain the types of moment resisting connections in a steel beam-column connection.
5. Explain the different collapse mechanisms in plastic analysis.

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Design a RC grid floor to cover a floor area of 11m x 16m. The spacing of ribs in mutually perpendicular direction is 1.6 m c/c. Live load on floor is 3 kN/m^2. Analyse the grid floor by IS 456 method and design suitable reinforcement for the grid floor.

7. Design an interior panel of a flat slab with panel size 6m x 6m by providing drop. The size of columns is (500 x 500) mm and live load on the panel is $4kN/m^2$. Use M20 grade concrete and Fe415 steel.

8. Design a continuous beam of two spans supported on stone masonry walls using the limit state method and allowing 15% redistribution of moments. The following data may be assumed.

   Clear span between the supports = 6m

   Width of masonry supports = 330mm

   Thickness of RC slab = 150mm, Spacing of continuous beams = 3m c/c

Self weight of floor finish = 0.4 kN/m^2, LL on the floor = 4kN/m^2

Characteristic cube strength of concrete = 20N/mm^2

Characteristic strength of steel = 415N/mm^2

9. Design a pile foundation under a column transmitting a load of 800kN. The pile is to be driven in to hard stratum available at a depth of 12m. Use M20 concrete and Fe 415 steel.

10. Design a bracket connection to transfer an end reaction of 225kN at an eccentricity of 300mm from the face of the column flange. Design a bolt joint connecting the Tee flange with the column flange.

11. A bracket plate 10mm thick is used to transmit a reaction of 100kN at an eccentricity of 140mm from flange. Design the weld.

12. An Industrial building of plan 15m×30m is to be constructed as shown in Fig.E1. Using plastic analysis, analyse and design the single span portal frame with gabled roof. The frame has a span of 15m, the column height is 6m and the rafter rise is 3m and the frames are spaced at 5m centre-to-centre. Purlins are provided over the frames at 2.7m c/c and support AC sheets. The dead load of the roof system including sheets, purlins and fixtures is 0.4kN/m^2 and the live load is 0.52kN/m^2.

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Syllabus

Module 1

Yield line method of analysis of slabs: – Characteristic features of yield lines, analysis by virtual work method, Yield line analysis by equilibrium method, Design of grid floor approximate method (IS code method)

Module 2

Design of flat slabs: – Introduction, components–IS Code recommendations, IS code method of design, with and without drop, interior and exterior panels.

Module 3

Design of continuous beams: - Redistribution of moments, Design concepts of Pile foundation: Pile and Pile cap design of end bearing piles.

Module 4

Beam-column connection in steel buildings: - Connection Configurations, Simple, Semi-rigid and Rigid Connections, Bolted frame connection, Bolted bracketed connection, Welded frame connection, Welded bracketed connection, Moment resistant connections.

Module 5

Industrial steel buildings: - Building configuration and components, Loads and load combinations, Industrial floor, Roof systems

Plastic analysis, Shape factor, Collapse mechanisms, Design of portal frames.

Course Plan

No	Topic	No. of Lectures
1	**Yield line method of analysis and grid floor design (8)**	
1.1	Concept of yield line and Characteristics	1
1.2	Virtual work method of analysis	2
1.3	Equilibrium method of analysis	2
1.4	Design of grid floor	3
2	**Design of flat slabs (8)**	
2.1	Introduction–components. IS code method of design	1
2.2	Design of flat slab with drop, interior and exterior panel design	3
2.3	Design of flat slab without drop, interior and exterior panel design	3
3	**Design of beams and foundation (8)**	
3.1	Design of continuous beams and IS code provisions	2
3.2	Redistribution of moment	2
3.3	Design of pile and pile cap for end bearing piles.	4
4	**Beam-column connection in steel buildings (9)**	
4.1	Types of connections and configurations	1

4.2	Simple, Semi-rigid and Rigid Connections	1
4.3	Design of bolted frame connection,	2
4.4	Design of bolted bracketed connection	2
4.5	Design of welded frame and bracketed connection	2
4.6	Moment resistant connections: concept only	1
5	**Industrial steel buildings: (9)**	
5.1	Introduction, building configuration and components	1
5.2	Loads and load combinations as per IS code	1
5.3	Industrial floors and roof systems	1
5.4	Plastic analysis, Shape factor	2
5.5	Collapse mechanisms: beam, sway, gable, joint and combined mechanisms	2
5.6	Design of portal frames	2

Reference Books

1. S. Unnikrishna Pillai, Devadas Menon, "Reinforced Concrete Design", Tata McGraw-Hill Publishing Company Ltd.
2. N. Krishna Raju., "Design of Reinforced Concrete Structures", CBS Publishers and Distributors.
3. B. C. Punmia, Ashok K Jain, Arun K Jain, "Reinforced Concrete Vol :II", Lakshmi Publications.
4. P. C. Varghese, "Limit State Design of concrete structures", Prentice Hall of India Private Ltd.
5. P. C. Varghese, "Foundation Engineering", Prentice Hall of India Private Ltd.
6. S. Ramamrutham, "Design of Reinforced Concrete Structures", Dhanpat Rai Publishing Company.
7. S. S. Bhavikatti , "Advance R.C.C Design Vol II", New Age International Private Limited
8. IS: 456-2000, SP 16, SP 24, SP 34.
9. N. Subrhamanyan, "Design of Steel Structures", Oxford Publication.
10. Horne, M.R. and Morris L.J., "Plastic Design of Low -rise frames", Granada Publishing.
11. S. K. Duggal, "Design of Steel Structure", Tata Mc Graw Hill.
12. Kuzamanovic B.O. and Willems N., "Steel Design for Structural Engineers", Prentice Hall.
13. IS: 800, "Code of practice for General Construction in steel".
14. IS: 875 - (Part I to V) – "Code of practice for structural safety of building loading standards"

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TCE002	CONSTRUCTION PLANNING, SCHEDULING AND CONTROL	PROGRAM CORE 2	3	0	0	3

Preamble: The course provides the concept of planning, scheduling and controlling techniques necessary for construction projects.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Estimateactivity durationand resource requirements for work activities.
CO 2	Analyse and apply Critical Path Method and PERT for construction schedules.
CO 3	Optimize resource requirements.
CO 4	Explain the latest trends in scheduling in the construction industry

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2		2	1			
CO 2	1		3	2			
CO 3	1		2				
CO 4			1				

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	15
Understand	20
Apply	25
Analyse	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewedoriginal publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:
The end semester examination will be conducted by the Univeristy. Therewill be two parts; Part A and Part B. Part A will contain 5 numerical/short answerquestions with 1 question from each module, having 5 marks for each question(such questions shall be useful in the testing of knowledge, skills, comprehension,application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code:221TCE002

CONSTRUCTION PLANNING, SCHEDULING AND CONTROL

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Explain the factors affecting choice of technology and construction method?
2. Define different types of activity floats.
3. Explain the concept of time cost trade off.
4. Describe the term 'Resource Levelling'.
5. Explain the indices which denote the time efficiency of construction projects.

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Explain with an example of concreting, the need for universal coding system for identifying activities.
7. The following details regarding the activities of a project are given.

Activity	A	B	C	D	E	F	G	H
Immediate Predecessor	None	None	A	A	A	B, C	D	E, F, G
Duration (weeks)	4	12	9	15	7.5	9	3.5	5

i. Prepare an Activity on Node Diagram.

ii. Prepare a schedule of activities.

iii. Find the expected duration of the project.

iv. Determine the critical activities.

v. Find the total and free floats of all activities.

8. The details given below pertain to a construction project. The three time estimates of activities are given as a, m and b.

i. Draw the AoN network, determine the critical path and the project completion time.

ii. What is the probability of not meeting the target time of 22 days

Activity		A	B	C	D	E	F	G
Predecessor		None	None	None	A	B	C	D, E
Duration (days)	a	1	1	2	2	3	2	2
	m	3	4	6	2	6	5	5
	b	5	7	10	8	15	8	14

9. The District Corporation intends to install a road traffic regulatory signal in a heavy traffic prone area. The total installation work has been broken down into six activities. The normal and crash durations and crash cost of the activities as expected are given in the table.

Activity	A	B	C	D	E	F
Predecessor	-	-	-	A	B	C, D, E
Normal time (days)	9	8	15	5	10	2
Crash time (days)	6	5	10	3	6	1
Crashing cost/day (Rs.)	30,000	40,000	45,000	15,000	20,000	60,000

i.Draw the project network and find the normal and minimum duration of the work.

ii.Compute the additional cost if the District Corporation wants to complete the project within the shortest possible duration.

10. How can resource planning be used to advantage in construction projects.
11. Explain the benefits of Management Information System.
12. Explain the significance of the following indices in Earned Value Analysis:

i.Schedule Variance

ii. Cost Variance

iii. Cost Performance Index.

Syllabus

Module 1

Basic concepts in the development of construction plans choice of technology and construction method - Defining work tasks – Defining precedence relationships among activities -Estimating activity duration.Estimating resource requirements for work activities - Coding Systems.

Module 2

Relevance of construction schedules. The Critical Path Method -Presenting project schedules with Activity - on - Node diagrams – Leads and Lags - Calculations for critical path scheduling -Activity floats and schedules -Scheduling with uncertain duration - Programme Evaluation and Review Technique - Calculations for Monte Carlo schedule simulation.

Module 3

Crashing and Time / Cost Tradeoffs - Resource oriented scheduling - Scheduling with resource constraints.

Module 4

Updating construction schedules – S curves – Management Information Systems.

Module 5

Earned Value Analysis - Measures of performance- Use of advanced scheduling techniques with awareness on scheduling software

Course Plan

No	Topic	No. of Lectures
1	**MODULE I (6 hours)**	
1.1	Basic concepts in the development of construction plans- Choice of technology and construction method	1
1.2	Defining work tasks – Defining precedence relationships among activities	2
1.3	Estimating activity duration	1
1.4	Estimating resource requirements for work activities -coding systems	2

2	**MODULE II (9 hours)**	
2.1	Relevance of Construction Schedules. The Critical Path Method	2
2.2	Presenting project schedules with Activity - on - Node diagrams, Leads and Lags	1
2.3	Calculations for critical path scheduling	1
2.4	Activity Float and Schedules	2
2.5	Scheduling with uncertain duration - Programme Evaluation and Review Technique	2
2.6	Calculations for Monte Carlo schedule simulation	1
3	**MODULE III (8 hours)**	
3.1	Crashing andTime / Cost Tradeoffs	2
3.2	Resource oriented scheduling	3
3.3	Scheduling with resource constraints	3
4	**MODULE IV (7 hours)**	
4.1	Updating construction schedules	3
4.2	S curves	1
4.3	Management Information Systems	3
5	**MODULE V (9 hours)**	
5.1	Earned Value Analysis - Measures of performance	3
5.2	Use of advanced scheduling techniques with awareness on scheduling software	6

Reference Books

1. Chitkara. K.K(1998) "Construction Project Management: Planning Scheduling and Control",Tata McGraw Hill Publishing Company, New Delhi,
2. Calin M. Popescu, ChotchalCharoenngam (1995), "Project Planning, Scheduling and Controlin Construction : An Encyclopaedia of terms and Applications", Wiley, New York, 34
3. Chris Hendrickson and Tung Au(2000), "Project Management for Construction – FundamentalConcepts for Owners, Engineers, Architects and Builders", Prentice Hall Pittsburgh,
4. Moder, J., C. Phillips and E. Davis (1983) "Project Management with CPM, PERT andPrecedence Diagramming", Van Nostrand Reinhold Company, Third Edition, Willis, E. M,Scheduling Construction Projects
5. John Wiley & Sons, Halpin, D. W (1985). "Financial and Cost Concepts for ConstructionManagement", John Wiley & Sons. New York.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LCE003	ADVANCED STRUCTURAL ENGINEERING LAB	LABORATORY	0	0	2	1

Preamble: To familiarize the students with the different sophisticated instrumentations used in the laboratory and field for testing materials and structural components. The lab also focuses on design of buildings, preparation of design drawings and scheduling construction projects.

Course Outcomes: After the completion of the course on Advanced Structural Engineering Lab, the student will be able to:

CO 1	Perform basic test for the constituent materials of concrete
CO 2	Perform mix design for various types of concrete as per IS guidelines
CO 3	Calibrate the instruments used in the lab
CO 4	Analyse the behaviour of steel and reinforced concrete structural elements.
CO 5	Perform scheduling of construction projects
CO 6	Prepare building drawings and lab reports

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1			1			
CO 2			2				
CO 3	1						
CO 4	2		2	1			
CO 5			2				1
CO 6		3					

(1-Weak, 2-Medium, 3- strong)

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100	–	–

Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

LIST OF EXPERIMENTS

Study of Instruments

1. Study of various instruments used for determining the material properties of concrete, steel, SCC etc
2. Study of instruments used for determining the durability of materials
3. Calibration of various instruments and equipment used in the lab

Material Testing and Mix Design

4. Review of testing methods of cement, coarse aggregate and fine aggregate as per Indian Standards.
5. Design of concrete mixes.

Testing of Concrete and Structural Members

6. Experimental study of behaviour of
   a) RCC structural elements
   b) Steel structural elements
7. Accelerated curing experiments for concrete.
8. Non- destructive testing of concrete
   a) Rebound hammer
   b) Core cutting
   c) Ultrasonic pulse velocity
   d) Pullout test
   e) Detection of embedded reinforcements

Building Design

9. Analysis and design of a multi-storied building using a suitable software
10. Preparation of detailed structural drawing of multi-storied structures using suitable CAD software
11. Development using BIM for 3D digital model visualization

Estimation and Scheduling

12. Activity identification and calculation of quantities of a multi-storied building.
13. Rate analysis and cost estimation of the building project
14. Preparation and delivery of the bid or proposal of an engineering construction project.
15. Scheduling and project planning using a suitable software.

General Instructions to Faculty:

Any 8 of the 15 experiments included in the list of experiments need to be performed mandatorily.

SEMESTER I

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE100	STRUCTURAL DYNAMICS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The course provides the basic concepts of structural dynamics and the theoretical background to perform dynamic analysis of structures. The course focuses on analysis of single and multi-degree of freedom systems. Anintroduction to distributed parameter systems is also given in the course.

Course Outcomes: After the completion of the course on Structural Dynamics, the student will be able to the following:

CO 1	Model single and multi-degree freedom systems for dynamic analysis and develop equations of motion
CO 2	Perform dynamic analysis of single degree freedom systems
CO 3	Perform dynamic analysis of multi - degree freedom systems
CO 4	Analyse and design vibration isolation systems
CO 5	Apply numerical techniques to solve vibratory systems and perform dynamic analysis using software.
CO 6	Perform dynamic analysis of distributed parameter systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		1	1			
CO 2	2		2	1	1		
CO 3	2		2	1	1		
CO 4	2		2	2	1		
CO 5	3		3	3	2		
CO 6	1		1				

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40
Analyse	20
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

The project shall be done individually. Group projects not permitted.

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern: The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B. Part A will contain 5 numerical/short answerquestions with 1 question from each module, having 5 marks for each question(such questions shall be useful in the testing of knowledge, skills, comprehension,application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating totheoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Note: The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE000

STRUCTURAL DYNAMICS

Max. Marks: 60 Duration: 2.5 hours

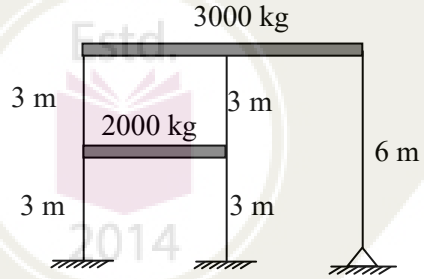
PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. A SDOF system with m = 20 kg, k = 12.5 kN/m and c = 1.5 kN-s/m is given an initial velocity of 50 m/s. Obtain the equation of displacement response and comment about the type of motion.

2. A simple beam of span 4 m having uniform cross section with moment of inertia 5×10^6 cm^4 supports at its centre a machine weighing 7000 kg. The motor runs at 300 rpm and its rotor is out of balance to an extent of 20 kg at an eccentricity of 250 mm. What will be the amplitude of the steady state response if the equivalent viscous damping of the system is assumed 10 % of critical? Neglect mass of the beam.

3. Develop spring-mass model of the shear building frame shown. Take flexural rigidity of all column as 250 kNm^2.



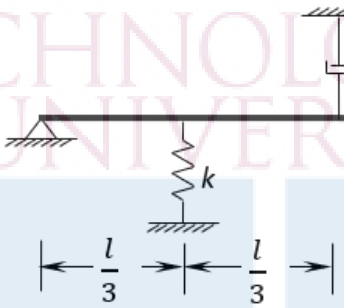
4. Derive the equation of motion for an undamped 2-DOF spring-mass system subjected to harmonic support motion

5. Explain Lagrange's equation. Derive the equation of motion of a SDOF spring-mass system using Lagrange's equation.

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. A rigid bar of length l having mass μ per unit length is hinged at one end and carries a mass m at the other end. It is supported using a spring and a viscous damper as shown in figure. Derive the equation of motion for small oscillations. Find the undamped natural frequency and critical damping coefficient.



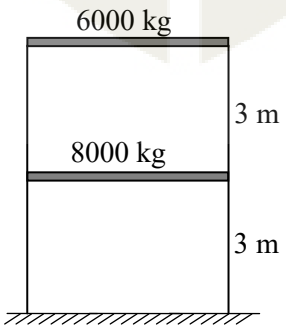
7. A delicate instrument of weight 200 kg is to be mounted on a factory floor using a vibration isolation suspension. The floor is vibrating with an amplitude of 0.25 mm and frequency 15 Hz. The maximum displacement that can be tolerated by the instrument for reliable operation is 0.1 mm. Find the stiffness of the suspension springs assuming 5% of critical damping.

8. A portable harmonic loading machine is used to conduct a test on a single storied building. Harmonic loads of magnitude 1960 N are applied at the floor level at two different frequencies. The test data is given below:

Frequency of load (rad/s)	Response amplitude (cm)	Phase angle (degrees)
8	1.50	7
10	2.25	13

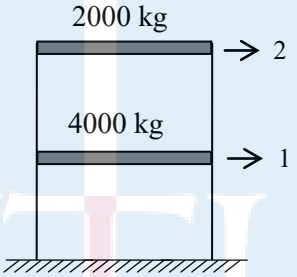
Evaluate the mass, stiffness and damping of the structure, assuming it as a SDOF spring-mass system.

9. Find the natural frequencies and mode shapes of the two storey shear building frame shown in figure. Flexural rigidity of the columns $= 2 \times 10^6$ Nm^2. Sketch the mode shapes also.



10. For a two degrees of freedom lumped mass system, $M = \begin{bmatrix} m & 0 \\ 0 & 2m \end{bmatrix}$; $K = \begin{bmatrix} 2k & -k \\ -k & 3k \end{bmatrix}$ and the modal matrix $\Phi = \begin{bmatrix} 1 & 1 \\ 1 & -0.5 \end{bmatrix}$. The natural frequencies are given by $\omega_1^2 = \frac{k}{m}$ and $\omega_2^2 = \frac{5}{2}\frac{k}{m}$. The first mass of the system is subjected to a harmonic force $P_0 \cos(\Omega t)$. Determine the response of each of the masses. Neglect damping.

11. For the frame shown in figure the natural frequencies are 15.81 rad/s and 31.62 rad/s. The modal matrix $\Phi = \begin{bmatrix} 1 & 1 \\ 2 & -1 \end{bmatrix}$. Neglecting damping, obtain the response of the floors due to a constant ground acceleration of $0.3g$, where $g = 9.81$ m/s^2.



12. Find the first three natural frequencies and mode shapes of a simply supported beam of span L having uniform flexural rigidity EI and mass $\overline{m}$ per unit length. Sketch the mode shapes also.

Syllabus

Module 1

Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion. Undamped and damped free vibration of single degree of freedom system.Measurement of damping from free vibration response - Logarithmic decrement.

Module 2

Response of single degree of freedom systems to harmonic loading, Measurement of damping from forced response – Half power band width method. Impulse response function, Response of single degree of freedom systems subjected to impulse, periodic and general loading- Duhamel integral. Single degree freedom subjected to support motion. Numerical solution of single degree of freedom systems –Central Difference Method - Newmark – β method.Vibration isolation –Transmissibility.Concept of tuned mass damper.

Module 3

Multi-degree of freedom (MDOF) systems – Equation of motion. Shear building concept and models for dynamic analysis –Evaluation of natural frequencies and mode shapes by solution of characteristic equation. Co-ordinate coupling - Orthogonality of normal modes.Mode superposition method of analysis, Free vibration response of MDOF systems due to initial conditions.

Module 4

Forced vibration analysis of multi-degree of freedom systems, Response of multi degree of freedom systems to support motion.Introduction to earthquake analysis, Response spectrum – concept.

Module 5

Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods.Flexural vibration of beams, natural frequencies and mode shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only), Variational formulation of the equation of motion – Hamilton’s principle - Lagrange’s equation.

Course Plan

No	Topic	No. of Lectures
Module I (9)		
1.1	Vibration studies and its importance to structural engineering applications – Types of dynamic loading – Systems with single degree of freedom – Elements of a vibratory system – Mathematical model for single degree of freedom systems - Equation of motion.	4
1.2	Undamped and damped free vibration of single degree of freedom system.	4
1.3	Measurement of damping from free vibration response - Logarithmic decrement.	1
Module II (9)		
2.1	Response of single degree of freedom systems to harmonic loading, Dynamic Magnification Factor. Measurement of damping from forced response – Half power band width method.	3
2.2	Impulse response function, Response of single degree of freedom systems subjected to step loading, rectangular and triangular impulses. Response to general loading- Duhamel integral.	3
2.3	Numerical solution of single degree of freedom systems – Central Difference Method - Newmark – β method.	3
Module III (9)		
3.1	Single degree of freedom system subjected to support motion. Vibration isolation –Transmissibility. Tuned mass damper.	2
3.2	Multi-degree of freedom systems – Equation of motion.	2
3.3	Shear building concept and models for dynamic analysis – Evaluation of natural frequencies and mode shapes by solution of characteristic equation.	3
3.4	Co-ordinate coupling –Orthogonality of normal modes.	1
3.5	Mode superposition method of analysis – free vibration response of MDOF systems.	1
Module IV (7)		
4.1	Forced vibration analysis of multi-degree of freedom systems.	4
4.2	Response of multi degree of freedom systems to support motion.	2
4.3	Introduction to earthquake analysis, Response spectrum – Concept.	1
Module V (6)		
5.1	Distributed mass (continuous) systems – differential equation of motion – Axial vibration of rods.	1
5.2	Flexural vibration of beams, natural frequencies and mode	3

	shapes of simply supported beam. Evaluation of frequencies and mode shapes of cantilever beam and fixed beam (formulation only).	
5.3	Variational formulation of the equation of motion – Hamilton's principle - Lagrange's equation.	2

Reference Books

1. Clough R W and Penzien J, Dynamics of Structures, McGraw Hill, New Delhi.
2. Biggs J M, Introduction to Structural dynamics, McGraw Hill, New Delhi.
3. Mario Paz, Structural Dynamics – Theory and Computation, CBS Publishers and Distributors, Delhi.
4. Mukhopadhyay M, Structural Dynamics - Vibrations and Systems, Ane Books India, Delhi.
5. Humar J, Dynamics of Structures, CRC Press, Netherlands.
6. Anil K Chopra, Dynamics of Structures- Theory and Application to Earthquake Engineering, Pearson Education, New Delhi.
7. Roy R Craig, Structural Dynamics – An Introduction to Computer Method, John Wiley & Sons, Newyork.
8. Thomson W T, Theory of Vibration with Application, Pearson Education, New Delhi.
9. Weaver W, Timoshenko S P, Young D H, Vibration Problems in Engineering, John Wiley & Sons, USA.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE001	THEORY OF ELASTICITY	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The course exposes the students to advanced concepts of strength of materials. Students are introduced to two- and three-dimensional problems in rectangular and polar coordinate systems to describe stress and strain in an elastic continuum. An introduction to plasticity is also provided.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop the concept of stress-strain tensors and their relationships in 3D continuum problems.
CO 2	Idealize physical problems into plane stress and plane strain problems and solve them using stress functions.
CO 3	Describe the state of stress and strain developed in solids due to applied loads
CO 4	Compute the effect of torsion in thin-walled and irregular closed/open sections.
CO 5	Apply various failure criteria for general stress states at points.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		1				
CO 2	1		2		1		
CO 3	1		1		1		
CO 4	1		3		1		
CO 5	1						

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	20
Evaluate	15
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE001

THEORY OF ELASTICITY

Max. Marks: 60 Duration: 2.5 hours

PART A

Answer all questions; each question carries 5 marks

1. Comment on Octahedral plane and octahedral stresses.
2. Differentiate between plane stress and plane strain problems with suitable examples.
3. What do you mean by strain energy and strain energy density?
4. Explain Prandtl's membrane analogy.
5. Scrutinise yield criteria and its significance.

PART B

Answer any five questions; each question carries 7 marks

6. The state of stress at a point is specified by the following stress components

$$\begin{bmatrix} 50 & 50 & 100 \\ 50 & 20 & 10 \\ 100 & 10 & 20 \end{bmatrix} \text{MPa}$$

Determine the principal stresses and check the feasibility of stress invariants.

7. Given the following stress function

$$\phi = x^3y + xy + y^3x$$

Determine the stress components and check whether it is a feasible stress function.

8. The strain components at a point on a steel object are €x = 0.001, €y = -0.003, €z = 0, €xy = 0, €yz = 0.015 and €xz = -0.001. E = 207x10^6 KPa and G = 80x10^6 KPa. Determine the value of strain energy density.
9. Derive the torsion equation and list out the assumptions used for the derivation.
10. Derive the governing differential equations of torsion problem by Saint-Venant's approach.
11. Write short notes on
    i. Stress strain curve for ductile material

ii. Yield surfaces
iii. Tresca's yield criteria

12. A circular shaft of inner radius 'r_1' and outer radius 'r_2' is subjected to a twisting moment so that the outer most fibre starts yielding. Determine the twisting moment applied to the shaft. Assume yield stress in shear for the shaft material equal to 'τ_0'. Also calculate the couple for full yielding and at elasto-plastic yielding.

SYLLABUS

Module 1

Basic concepts– Body force–Surface traction–Stresses and strains, Three dimensional stresses and strains – analysis, Transformation equations of 3D stresses & strains, Principal stresses & strains, States of stresses & strain, Equilibrium equations.

Module 2

Plane stress and plane strain– Analysis, Transformation equations, stress–strain relations, Equilibrium equations in Cartesian and polar coordinates, Airy's stress function– Biharmonic Equilibrium, Saint Venant's principle, 2D problems in Cartesian coordinate, Cantilever with concentrated load at free end, Cantilever with moment at free end.

Module 3

Strain Energy Density, Complementary Internal Energy Density, Elasticity and Strain Energy Density, Elasticity and Complementary Internal Energy Density, Generalized Hooke's Law, Anisotropic Elasticity, Isotropic Elasticity, Displacements-strains and compatibilityequations, Equilibrium equations and boundary conditions

Module 4

Torsion of prismatic bar– General solution, warping function approaches Saint Venant'stheory, warping function approaches Prandtl's stress function, Membrane analogy-torsion of irregular cross sections, Torsion of narrow rectangular cross sections, Torsion of multi celled thin wall open and closed sections.

Module 5

Introduction to plasticity – General concepts, Stress – Strain curve, Ideal plastic body – Plastic flow conditions,Theories of failure, Yield criteria – Simple applications, Elasto – plastic analysis for bending and torsion of bars, Residual stresses in bending and torsion.

Course Plan

No	Topic	No. of Lectures
1	**Module I : Elasticity (8)**	
1.1	Basic concepts– Body force–Surface traction–Stresses and strains	1
1.2	Three dimensional stresses and strains – analysis	1
1.3	Transformation equations of 3D stresses& strains	2
1.4	Principal stresses & strains	2
1.5	States of stresses & strain	1
1.6	Equilibrium equations	1
2	**Module II: Two-dimensional stress–strain problems (8)**	
2.1	Plane stress and plane strain– Analysis	1
2.2	Transformation equations, stress–strain relations	1
2.3	Equilibrium equations in Cartesian and polar coordinates	1
2.4	Airy's stress function– Biharmonic Equilibrium	2
2.5	Saint Venant's principle, 2D problems in Cartesian coordinate	1
2.6	Cantilever with concentrated load at free end	1
2.7	Cantilever with moment at free end.	1
3	**Module III: Elements of Theory of Elasticity (8)**	
3.1	Strain Energy Density	1
3.2	Complementary Internal Energy Density	1
3.3	Elasticity and Strain EnergyDensity,Elasticity and Complementary Internal Energy Density	2
3.4	Generalized Hooke's Law	1
3.5	Anisotropic Elasticity, Isotropic Elasticity	1
3.6	Displacements-strains and compatibility equations	1
3.7	Equilibrium equations and boundary conditions	1
4	**Module IV: Torsion (8)**	
4.1	Torsion of prismatic bar– General solution	1
4.2	Warping function approaches Saint Venant's theory.	1
4.3	Warping function approaches Prandtl's stress function	1
4.4	Membrane analogy-torsion of irregular cross sections	2
4.5	Torsion of narrow rectangular cross sections.	1
4.6	Torsion of multi celled thin wall open and closed sections.	2
5	**Module V: Plasticity (8)**	
5.1	Introduction to plasticity – General concepts, Stress – Strain curve	1
5.2	Ideal plastic body – Plastic flow conditions	1
5.3	Theories of failure	1
5.4	Yield criteria – Simple applications	1
5.5	Elasto –plastic analysis for bending and torsion of bars	2
5.6	Residual stresses.	2

Reference Books

1. Timoshenko S P and Goodier J. N, “Theory of Elasticity”, Tata McGraw HillInternational Student Edition.
2. Sadhu Singh, “Theory of Plasticity”, Khanna Publishers, Delhi
3. Srinath L. S, “Advanced mechanics of solids”, Tata McGraw– Hill Publishing CompanyLtd., New Delhi.
4. T. G. Seetharam, L. GovindaRaju, “Applied Elasticity”.Arthur P Boresi& Omar M SideBottom, “Advanced Mechanics of Materials”, John Wiley& Sons.
5. Sokolnikoff, “Mathematical Theory of Elasticity”, McGraw-Hill Inc.,US.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE002	MODERN CONSTRUCTION MATERIALS	Program Elective 1	3	0		3

Preamble: The main objective of this course is to develop a strong understanding of the material science of various construction materials and its influence on the performance of the materials in the structure.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Relate the fundamentals of materials science with properties and behaviour of materials.
CO 2	Explain the properties of various construction materials
CO 3	Explain the failure behaviour of materials under different loading conditions
CO 4	Decide the appropriateness of a material for a specific application

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			2				
CO 2			2				
CO 3	1		2		2		
CO 4	1			1	2	1	

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	20
Apply	20
Analyse	15
Evaluate	5

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions.

Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE002

MODERN CONSTRUCTION MATERIALS

Time: 2.5 hrs. Max. Marks: 60

PART A

(Each question carries 5 marks. Answer ALL questions)

1 Explain any two types of chemical bonds and their influence on material properties.

2 How the slip along the atomic planes affects the material behaviour?

3 Explain any one rheological model. Also describe the suitability of that model for practical condition.

4 Explain how the micro structure of concrete influence its macro behaviour.

5 Explain the application of any two smart and intelligent materials used in construction industry. Correlate the material structure with the application.

PART B

(Each question carries 7 marks. Answer any 5 questions)

6 Describe wetting behaviour of liquids on solids. Also describe how this fundamental understanding can lead to development of new materials.

7 What is rheology? Explain the rheological parameters and their influence in the flow of liquids.

8 Explain the significance of target compressive strength and target mean strength in concrete mix design.

9 Describe the characteristics of bitumen and asphalt concrete. Explain why bitumen is a competitive choice as a pavement construction material.

10 Relate the properties of TMT steel with its production process. Explain why TMT steel is a better choice for buildings in earthquake prone area.

11 Explain the various failure theories. Give a comparison between them in terms of confining pressure.

12 Explain the structure, properties and applications of Fibre Reinforced Plastics.

Syllabus

Module 1

Bonds - Review of chemical bonds, states of matter, structure of materials, Movement of atoms, Development of microstructure;
Surface Properties: Introduction to Surface Energy, Surface Tension, wetting, Adhesion, Adsorption, Surfactants, Capillary Rise, Colloids.

Module 2

Review of mechanical behaviour - Deformation, Stress, Strain, Hooke's Law, Stress-Strain Diagram; Response to stress – Elastic Properties, Plasticity, Yielding, Slip along atomic planes, Strain Hardening, Annealing; Response to stress - Ductile Failure, Brittle Fracture, Fatigue Failure, Creep; Probabilistic Fracture -Tensile and Compressive Strengths, Statistics of Strength;
Failure theories – Uni axial (Tensile) Behaviour of a Metal, Complex Inelastic Response, Multi axial Loading, Introduction to Rankine Theory, Tresca Criterion, von Mises Theory, Mohr coulomb Failure Theory

Module 3

Introduction to Fracture Mechanics - Stress concentration, Pure modes of fracture - Mode I or opening crack, Linear Elastic Fracture Mechanics, Brittle Ductile Transition, Brittle Fracture, Elasto-Plastic Fracture; Fracture in Polymers, Fracture in Composites, Fracture in Concrete.
Rheology - Time-Dependent Material Response, Rheological Models, Rheological Behaviour of Liquids, Thixotropy;
Thermal properties - Heat Capacity, Thermal Expansion, Thermal Stresses, Thermal Conductivity

Module 4

Metals - Structure, Properties and Applications of Iron and Steel, Aluminium;
Timber - Structure of Wood, Properties of Wood, Seasoning of Timber, Engineering Properties, Thermal Properties, Applications of Timber, Wood-Based Composites;
Concrete - Structure, Properties and Applications

Module 5

Bituminous materials - Structure of Bitumen, Specification of Bitumen, Asphalt Concrete Paving Mixtures;
Polymers and Plastics - Structure, Properties and Applications; FRP - Structure, Properties and Application; Glass – Types, properties and applications,
Smart and intelligent materials (shape memory alloys, magnetostrictive materials, piezo electric materials)

Course Plan

No	Topic	No. of Lectures
1	**Review of bonds; development of micro structure; surface properties**	
1.1	Introduction to the subject – Need to understand the material structure – Relationship between micro structure to macro structure behaviour	1
1.2	Bonds - Review of chemical bonds, states of matter, structure of materials	1
1.3	Movement of atoms, development of microstructure	2
1.4	Surface Properties: Introduction to Surface Energy, Surface Tension, Wetting, Adhesion	2
1.5	Surface Properties: Adsorption, Surfactants, Capillary Rise, Colloids	2
2	**Mechanical behaviour of materials; Failure theories**	
2.1	Review of mechanical behaviour - Deformation, Stress, Strain, Hooke's Law, Stress-Strain Diagram	1
2.2	Elastic Properties, Plasticity, Yielding, Slip Along Atomic Planes, Strain Hardening, Annealing	2
2.3	Ductile Failure, Brittle Fracture, Fatigue Failure, Creep.	1
2.4	Probabilistic Fracture -Tensile and Compressive Strengths, Statistics of Strength	1
2.5	Failure theories – Uni axial (Tensile) Behaviour of a Metal, Complex Inelastic Response, Multi axial Loading	1
2.6	Introduction to Rankine Theory, Tresca Criterion, von Mises Theory, Mohr-Coulomb Failure Theory	2
3	**Fracture mechanics; Rheology**	
3.1	Introduction to fracture Mechanics - Stress Concentration, Pure Modes of Fracture-Mode I or opening crack, Linear Elastic Fracture Mechanics, Brittle-Ductile Transition, Brittle Fracture, Elasto-Plastic Fracture	2
3.2	Fracture in Composites, Fracture in Concrete	2
3.3	Rheology - Time-Dependent Material Response, Rheological Models, Rheological Behaviour of Liquids, Thixotropy;	2
3.4	Thermal properties - Heat Capacity, Thermal Expansion, Thermal Stresses, Thermal Conductivity	2
4	**Structure, Properties and Application of Materials – Metals, Timber, Concrete**	
4.1	Metals - Structure, Properties and Applications of iron, steel and aluminium	2
4.2	Timber - Structure of Wood, Properties of Wood, Seasoning of Timber,	1
4.3	Engineering Properties, Thermal Properties, Applications of Timber	1
4.4	Wood-Based Composites	1
4.5	Concrete - Structure, Properties and Applications	3

5	**Structure, Properties and Application of Materials – Bitumen, Polymers and plastics, FRP, Glass, Smart and intelligent materials**	
5.1	Bituminous materials - Structure of Bitumen, Specification of Bitumen, Asphalt Concrete Paving Mixtures	2
5.2	Polymers and Plastics - Structure, Properties and Applications	2
5.3	FRP - Structure, Properties and Applications	1
5.4	Glass – Types, Properties and Applications	1
5.5	Smart and intelligent materials (shape memory alloys, magnetostrictive materials, piezo electric materials)	2

Reference Books

1. J.F. Young, S. Mindess, R.J. Gray and A. Bentur, "The Science and Technology of Civil Engineering Materials", Prentice Hall, 1998
2. W.D. Callister, "Materials Science and Engineering: An introduction", John Wiley, 1994
3. J.M. Illston and P.L.J. Domone, "Construction Materials: Their nature and behaviour", Spon Press, 2001
4. P. Kumar Mehta and Paulo J. M. Monteiro, "Concrete, Microstructure, Properties and Materials", Indian Concrete Institute, Chennai.
5. V. Raghavan, "Materials Science and Engineering: A first course", Prentice Hall, 2004
6. R.A. Higgins, "Properties of Engineering Materials", Industrial Press, 1994
7. J.M. Gere, "Mechanics of Materials", Nelson Thornes, 2001
8. T.L. Anderson, "Fracture Mechanics: Fundamentals and applications", CRC Press, 1991
9. M.F. Ashby and D.R.H. Jones, "Engineering Materials 1", Elsevier, 2005
10. P.C. Varghese, "Building Materials", Prentice-Hall India, 2005.
11. A.M. Neville, "Properties of Concrete", Pearson Education, Delhi, 2004.

NPTEL Course for reference:

- NPTEL course on "Modern Construction Materials", Prof. Ravindra Gettu, IIT Madras
  https://onlinecourses.nptel.ac.in/noc20_ce05/preview

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE003	ADVANCED CONSTRUCTION TECHNIQUES	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The course helps to study and understand various advanced construction techniques applied to engineering construction. The course covers construction practices for substructure and superstructures of heavy structures, construction sequences of various infrastructures and the different repairing techniques used in construction. Advanced techniques for demolition and dismantling of structure is also included.

Course Outcomes: After the completion of the course on Advanced Construction Techniques the student will be able to

CO 1	Describe the construction practices for sub structures and super structures of heavy structures.
CO 2	Explain the construction sequences of various infrastructures.
CO 3	Describe various repairing techniques in construction.
CO 4	Describe the advanced techniques in demolition and dismantling of structures.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			1		1		
CO 2			1		1		
CO 3			1		1		
CO 4			1		1		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	15
Understand	20
Apply	25
Analyse	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE003

ADVANCED CONSTRUCTION TECHNIQUES

Max. Marks: 60 **Duration: 2.5 hours**

PART A

(Answer ALL questions; each question carries 5 marks)

1. Describe the process of pipe jacking.
2. Discuss in detail about vacuum dewatering of concrete flooring.
3. Elaborate the construction sequence of silos.
4. Write a note on mud jacking.
5. Explain the sequence in which demolition of a building is carried out.

PART B

(Answer any FIVE questions; each question carries 7 marks)

6. What do you understand by deep-well dewatering systems?
7. What are the different launching techniques used for bridge construction? Explain in detail.
8. Make a detailed note on aerial transportation.
9. Describe the sequence of a bow string bridge construction.
10. Explain in detail about concrete paving technology.
11. Elaborate the process and techniques of laying underwater pipelines.
12. Discuss about the processing and disposal of demolition waste.

****

Syllabus

Module 1

Sub structure construction- Box jacking and pipe jacking, Under water construction of diaphragm wall and basement, Tunnelling techniques, Piling techniques, Driving well and caissons, Sinking of cofferdams, Dewatering, underground excavation.

Module 2

Super structure construction- Concrete paving technology, Techniques of construction for continuous concreting operations in tall buildings of various shapes and various sections, Suspended formwork, Erection techniques of tall structures, Large span structures, Launching techniques. Ariel transporting.

Module 3

construction sequences - Erecting lattice tower, Construction sequence of cooling towers and chimneys, Construction sequence of silos, Construction sequence of skyscrapers, Sequence of bowstring bridges, Cable stayed bridges.

Module 4

Construction repair- waterproofing on concrete, pipeline laying, protecting sheet piles, mud jacking grout through slab foundation, micro piling for strengthening floor and shallow profile, subgrade waterproofing.

Module 5

Advanced techniques and sequence in demolition and dismantling- Types and methods of demolition, Preparatory operations before demolition and steps, Demolition sequence, Demolition equipment, Demolition waste processing and disposal, Demolition hazards.

Course Plan

No	Topic	No. of Lectures
1	**Sub Structure Construction (8)**	
1.1	Box jacking and pipe jacking	1
1.2	Under water construction of diaphragm wall and basement	1
1.3	Tunnelling techniques	1
1.4	Piling techniques, Driving well and caissons	2
1.6	Sinking of cofferdams	1
1.7	Dewatering	1
1.8	Underground excavation	1
2	**Super Structure Construction (7)**	
2.1	Concrete paving technology	1
2.2	Techniques of construction for continuous concreting operations in tall buildings of various shapes and various sections	1
2.3	Suspended formwork	1
2.4	Erection techniques of tall structures	1
2.5	Large span structures	1
2.6	Launching techniques	1
2.7	Ariel transporting	1
3	**Construction Sequences (8)**	
3.1	Erecting lattice tower	1
3.2	Construction sequence of cooling towers and chimneys	2
3.3	Construction sequence of silos	1
3.4	Construction sequence of skyscrapers	2
3.5	Sequence of bowstring bridges	1
3.6	Sequence of cable stayed bridges	1
4	**Construction Repair (7)**	
4.1	Waterproofing on concrete	2
4.2	Pipeline laying	1
4.3	Protecting sheet piles	1
4.4	Mud jacking grout through slab foundation	1
4.5	Micro piling for strengthening floor and shallow profile	1
4.6	Subgrade waterproofing	1
5	**Advanced Techniques And Sequence In Demolition And Dismantling (6)**	
5.1	Types and methods of demolition	1
5.2	Preparatory operations before demolition and steps	1
5.3	Demolition sequence	1
5.4	Demolition equipments	1

5.5	Demolition waste processing and disposal	1
5.5	Demolition hazards	1

Reference Books

1. Mohammad Najafi (2021), *Trenchless Technology: Pipeline and Utility Design, Construction, and Renewal.* The McGraw-Hill
2. Robert T. Ratay (2012), *Temporary Structures in Construction, Third Edition.* McGraw-Hill
3. Alan Macnab (2002), *Earth Retention Systems Handbook.* The McGraw-Hill Companies, Inc.
4. Richard Lambeck , John Eschemuller (2009), *Urban Construction Project Management. McGraw-Hill Construction Series.* (*1st edition*). The McGraw-Hill Companies, Inc.
5. P. Kumar Mehta, Paulo J.M Monterio (2014), *Concrete: microstructure properties and materials,4th edition.* The McGraw-Hill Companies, Inc.
6. Robert T. Ratey (2010), *Forensic Structural Engineering Handbook, Second Edition*.The McGraw-Hill Companies, Inc.
7. Kristian B Dahl1, Aja Anta Mageroy Tonnessen (2017), *Tresfjord Bridge – a human friendly and traffic efficient structure.* IOP Publishing
8. Mohiuddin A. Khan (2010), *Bridge and Highway Structure Rehabilitation and Repair.* McGraw-Hill Education
9. Alexander James Wallis-Tayler (2017), *Aerial or wire-rope tramways; their construction and management,* Andesite Press
10. Joseph J. Carr, George W. Hippisley (2012), *Practical Antenna Handbook, 5th edition*
11. Eric Kleinert (2015), *HVAC and Refrigeration Preventive Maintenance, 1st Edition.* McGraw-Hill Education
12. Albert Allison Houghton (2012), *Practical Silo Construction; A Treatise Illustrating and Explaining the Most Simple and Easiest Practical Methods of Constructing Concrete Silos of All Types; With Unpatented Forms and Molds.* Hardpress Publishing
13. Akbar R. Tamboli (2012), *Tall and Supertall Buildings: Planning and Design,* McGraw-Hill Education
14. Roger L. Brockenbrough, Frederick S. Merrit (2020), *Structural Steel Designer's Handbook, Sixth Edition.* McGraw-Hill Education
15. Alexander Newman (2021), *Structural Renovation of Buildings: Methods, Details, and Design Examples, Second Edition.*. McGraw-Hill Education

16. Robert W. Day (2010), *Foundation Engineering Handbook: Design and Construction with the 2009 International Building Code, 2nd Edition*.The McGraw-Hill Companies, Inc.

17. M. Rashad Islam (2022), *Construction Safety: Health, Practices, and OSHA,1st Edition*. McGraw Hill

18. George Tchobanoglous, Frank Kreith (2002), *Handbook of Solid Waste Management, 2nd Edition.* The McGraw-Hill Companies, Inc.

SEMESTER I

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE006	FINITE ELEMENT METHOD	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The course aims to give a fundamental knowledge on finite element method. Students will be able to comprehend FEM as a numerical technique to solve partial differential equations representing various problems in structural mechanics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the structures using energy principles and variational formulation
CO 2	Explain the procedure of finite element method and derive the shape functions of various elements
CO 3	Derive the stiffness matrix of various elements used for the analysis of structures
CO 4	Analyse of structures using finite element techniques

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1		1				
CO 2	1		1				
CO 3	1		1				
CO 4	1		3	2	2		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	20
Evaluate	15
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

The project shall be done individually. Group projects not permitted.

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE006

FINITE ELEMENT METHOD

Max. Marks: 60 Duration: 2.5 hours

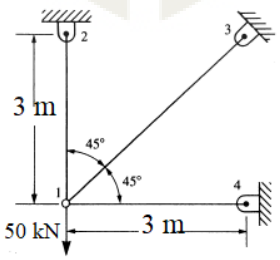
Answer all questions; each question carries 5 marks

1. What is meant by structural idealisation
2. Define degree of continuity and differentiate C0 and C1 elements
3. Explain the significance of static condensation in FEA
4. Evaluate the integral I = $\int_{-1}^{1}(3^x - x)dx$ using two and three Gauss points
5. Compare the structural behaviour of thin and thick plates with the help of classical plate bending theories

PART B

Answer any five questions; each question carries 7 marks

6. Analyse a cantilever beam subjected to concentrated load "W" at free end using Rayleigh Ritz method
7. Derive the shape functions of beam element using Hermition interpolation
8. Analyse the given assembly of truss elements using finite element techniques and determine the x and y displacements at node 1. Also determine stress in each element. E = 2.0x10^6 Pa and A= 15cm^2 for all elements



9. What are isoparametric elements? derive the stiffness matrix of plane bilinear isoparametric element

10 Discuss about displacement functions for plate elements. Prove that rectangular plate element with 12 degrees of freedom is not fully compatible

11 Explain the design procedure of finite element analysis

12 Derive shape functions of quadratic quadrilateral element having 9 nodes using Lagrange interpolation

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Syllabus

Module 1

Introduction to Finite Element Method – Historical development – Advantages – disadvantages – Outline of the FE procedure

Basics of elasticity - Equations of equilibrium – Strain -displacement relation – stress - strain (constitutive) relation- Plane stress and plane strain problems

Energy principles -Principle of virtual work - Approximate methods – Rayleigh Ritz method – Weighted Residual Method

Module 2

Displacement functions - convergence and compatibility requirements –- Types of finite elements - Degree of continuity– C0 and C1 elements

Shape functions – General coordinates – Natural coordinates - Development of shape functions for truss, CST, LST and beam elements

Shape functions of beam element using Hermition interpolation

Lagrange and Serendipity elements – Shape functions using Lagrange interpolation

Module 3

Development of stiffness matrix for bar element, beam elements and triangular elements

Development of consistent nodal load vector- patch test - static condensation.

Analysis of assembly of 2D truss elements, plane frames using finite element techniques

Module 4

Numerical integration - Gauss quadrature technique

Concept of isoparametric formulation- Plane bilinear element- Subparametric and superparametric elements

Module 5

Analysis of plate bending – Basic equation of thin plate theory- Reissner-Mindlin theory – plate elements and applications

Introduction to shell elements

Assembly procedure and storage techniques of stiffness matrix- Band width minimization – Gauss elimination

Discussion of modelling and analysis using recent finite element software packages

Course Plan

No	Topic	No. of Lectures
1	**Module I : Total lecture hours : 11**	
1.1	Historical development of FEA – Advantages and disadvantages	1
1.2	Outline of Finite Element Procedure	1
1.3	Basics of elasticity	1
1.4	Plane stress and plane strain problems	1
1.5	Energy principles - Principle of virtual work - Principle of stationary potential energy	1
1.6	Rayleigh Ritz method	3
1.7	Weighted residual method – Galerkin method	3
2	**Module II : Total lecture hours : 8**	
2.1	Convergence and compatibility requirements of displacement functions	1
2.2	Types of finite elements, Degree of continuity - C0 and C1 elements	1
2.3	General coordinates and Natural coordinates	1
2.4	Development of shape functions for truss elements, CST elements, LST elements	2
2.4	Development of shape functions for beam element using Hermitian interpolation	1
2.5	Lagrange and Serendipity elements, Shape functions of 1D and 2D elements by Lagrange interpolation	2
3	**Module III : Total lecture hours : 8**	

3.1	Development of stiffness matrix for bar element, beam element	1
3.2	Development of stiffness matrix for triangular elements	1
3.3	Development of consistent nodal load vector	1
3.4	Patch test - Static Condensation.	1
3.5	Analysis of assembly of 2D truss elements using finite element techniques	2
3.6	Analysis of plane frame using finite element techniques	2
4	**Module IV : Total lecture hours : 8**	
4.1	Numerical integration - Gauss quadrature technique	2
4.2	Concept of isoparametric formulation,	1
4.3	Isoparametric formulation of Plane bilinear element	2
4.4	Subparametric and superparametric elements	1
4.5	Numerical problems on Isoparametric formulation	2
5	**Module V : Total lecture hours : 8**	
5.1	Analysis of plate bending – Basic equation of thin plate theory- Reissner-Mindlin theory – plate elements and applications	3
5.2	Introduction to shell elements	1
5.3	Assembly procedure and storage techniques of stiffness matrix- Band width minimization	2
5.4	Gauss Elimination	1
5.4	Discussion of modelling and analysis using recent finite element ssoftware packages	1

Reference Books

1. Cook R D et al., Concepts and Applications of Finite Element Analysis, John Wiley & Sons, Singapore.
2. Krishnamoorthy C S, Finite Element Analysis- Theory and Programming, Tata McGraw Hill, New Delhi
3. Rajasekharan S, Finite Element Analysis in Engineering Design, Wheeler, New Delhi
4. Chandrupatla T R and Belegundu A D, Introduction to Finite Elements in Engineering, Pearson Education, New Delhi
5. Bathe K J, Finite Element Procedures in Engineering Analysis, Prentice Hall, New Delhi
6. Zienkiewicz O C and Taylor R W., Finite Element Method, Elsevier Butterworth-Heinemann, UK
7. Logan D L, A First Course in Element Method, Thomson, 2007

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE007	HIGH RISE STRUCTURES	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: Due to urbanization and lack of land, it has become inevitable to construct high rise structures. This subject will make the students aware of the various structural systems for high rise structures and the suitability of each towards different varying parameters. The course provides the basic principles involved in the design of high-rise structures. Different types of loads acting on a high-rise building are to be discussed after which the structural system required to take these loads are to be dealt with. The methods of analysis of high-rise structure are also to be discussed.

Course Outcomes: After the completion of the course on High-Rise Structures the student will be able to

CO 1	Describe the design philosophy and design criteria for tall buildings.
CO 2	Identify the characteristics of wind and earthquake loads acting on high rise structure.
CO 3	Choose and apply appropriate structural systems for different sizes and heights of structures
CO 4	Analyse the effect of gravity and lateral loads on structural members of tall structures.
CO 5	Analyse the behaviour of different structural forms and systems to carry lateral loads of high-rise structures
CO 6	Apply modelling and analysis methods for high rise buildings.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			2				
CO 2	1		2				
CO 3	1		3	2	1		
CO 4	1		2				
CO 5	1		2				
CO 6	2		3		1		

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	
Understand	
Apply	40

Analyse	20
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code: 222ECE007

HIGH-RISE STRUCTURES

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Explain the factors affecting the growth, height and structural forms of tall buildings.
2. Discuss the different types of gravity loads and associated parameters to be considered for the analysis and design of a tall building.
3. List with sketches, three floor systems suitable for high rise structures.
4. Explain the behaviour of high-rise structures with braced frames.
5. Discuss the advantages of outrigger braced structure over core structure.

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Discuss the design criteria for high rise structures.
7. Explain the need of wind tunnel test. What are the different types of wind tunnel experiments for high rise buildings.
8. Explain the different performance levels of building considered in Performance based seismic design.
9. A three-span beam each of 4m span carries a dead load of 6 kN/m for all the spans and 4kN/m for the two consecutive spans from right. Determine the support moments for the beams, if it is simply supported through out.
10. Discuss the advantage of a wall frame structure over framed or wall structures.
11. Discuss the different types of modelling for high rise structures.

****

Syllabus

Module – 1

Definition and need of tall building - Historic background - factors affecting growth. Design Criteria, Design Philosophy of High-Rise structures, Materials for construction of high rise structures.

Module – 2

Different types of Loadings – Gravity Loads, Wind Load, Static and Dynamic methods, Wind Tunnel test, Seismic Load, Performance Based Seismic Design

Module – 3

Structural form, Floor systems, Rigid frame Structures, Portal method, Cantilever method, approximate analysis of drift

Module – 4

Braced frames, Infilled frames, behaviour of infilled frames Shear wall Structures-behaviour of shear wall structures, Coupled shear walls, Wall frame structures- behaviour of wall frame.

Module – 5

Tubular structures-framed tube structures-bundled tube structures-braced tube structures, Core structures, Outrigger-Braced Structures, Foundations for tall structures-pile foundation-mat foundation, Modelling for analysis for high rise structures – approximate analysis, accurate analysis and reduction techniques, Discussion of various Finite Element Packages for the analysis of High-Rise Structures.

Course Plan

No	Topic	No. of Lectures
Module – 1		
1.1	Definition and need of tall building - Historic background - factors affecting growth	1
1.2	Design Criteria, Design Philosophy of High-Rise structures	2
1.3	Materials	2
2.1	Dead and live load, live load reduction techniques	2
Module – 2		
2.2	Sequential loading, Impact loading	1
2.3	Wind Loading - Wind Characteristics, Static and Dynamic wind effects - Analytical and wind tunnel experimental method	3

2.4	Seismic Loading - Earthquake loading-equivalent lateral force method, modal analysis, Introduction to Performance based seismic design	3
Module – 3		
3.1	Structural form, Floor systems, Rigid frame Structures, rigid frame behaviour	3
3.2	Approximate determination of member forces by gravity loading-two cycle moment distribution	3
3.3	Approximate determination of member forces by lateral loading-Portal method, Cantilever method	2
Module – 4		
4.1	Braced frames- Types of bracings-behaviour of bracings, behaviour of braced bents-method of member force analysis-method of drift analysis	2
4.2	Infilled frames, behaviour of infilled frames-stresses in infill-forces in frame- design of infill and frame (no numerical)-horizontal deflection	2
4.3	Shear wall Structures-behaviour of shear wall structures - proportionate wall systems, non-proportionate wall systems (no analysis required)- horizontal deflection, Coupled shear walls - behaviour of coupled wall structures	2
4.4	Wall frame structures- behaviour of wall frames	2
Module – 5		
5.1	Tubular structures-framed tube structures-bundled tube structures-braced tube structures	1
5.2	Core structures, Outrigger-Braced Structures	1
5.3	Foundations for tall structures-pile foundation-mat foundation	2
5.4	Modelling for analysis for high rise structures – approximate analysis, accurate analysis and reduction technique.	2
5.5	Discussion of various Finite Element Packages for the analysis of High-Rise Structures	1

Text Books

1. Bryan Stafford Smith and Alex Coull, Tall Building structures: Analysis and Design, Wiley-Interscience, New York, 1991.

2. Bungale S Taranath, Structural Analysis and Design of Tall Buildings, Tata McGraw Hill,1988.

Reference Books

1. Robert L Wiegel, Earthquake Engineering. Prentice Hall, 1970.

2. Kolousek V, Pimer M, Fischer O and Naprstek J, Wind effects on Civil Engineering Structures. Elsevier Publications, 1984

3. IS 16700:2017, Criteria for Structural Safety for Tall Concrete Buildings, BIS

4. High Rise Building Structures, Wolfgang Schueller, Wiley

5. Designing and installation of services in building complexes and high rise buildings, Jain, V.K., Khanna Publishers, New Delhi.

6. High rise structures; design and constructions practices for middle level cities, Gupta, Y.P., New Age International Publishers, New Delhi..

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE008	CONSTRUCTION MANAGEMENT AND ENGINEERING ECONOMICS	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The course provides a basic awareness of scientific management thoughts and an in-depth knowledge of projects, the various types and their planning and management. The students will be exposed to the concepts of engineering economics which will facilitate economic decision-making. Students are introduced to systematic knowledge of management information systems in decision-making.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Describe the concept and basic principles of scientific management and the various phases in the planning of construction projects
CO 2	Explain MIS effectiveness, efficiency criteria and failure ofMIS
CO 3	Apply the concepts of engineering economics in economic decision making
CO 4	Describe construction accounting and long-term and short-termfinancing
CO 5	Describe the need for PPP projects and the importance of risk allocation inthe projects and compare and contrast the various PPP models

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			1				1
CO 2			1				1
CO 3			2	2			1
CO 4			1				1
CO 5			1				1

(1-Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	15
Understand	20
Apply	25
Analyse	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewedoriginal publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. Therewill be two parts; Part A and Part B. Part A will contain 5 numerical/short answerquestions with 1 question from each module, having 5 marks for each question(such questions shall be useful in the testing of knowledge, skills, comprehension,application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (suchquestions shall be useful in the testing of overall achievement and maturity of thestudents in a course, through long answer questions relating tothe theoretical/practical knowledge, derivations, problem solving and quantitativeevaluation), with minimum one question from each module of which studentshould answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE:

Reg No.:_____

Name:_____ ___

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH. DEGREE EXAMINATION, MONTH & YEAR

Course Code:221ECE008

CONSTRUCTION MANAGEMENT & ENGINEERING ECONOMICS

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer ***ALL*** questions; each question carries 5 marks)

1. Describe the principles of scientific management.
2. Explain database Management.
3. Discuss Time value of money.
4. Explainconstruction accounting.
5. Explain operation and maintenance contracts.

PART B

(Answer ***any FIVE*** questions; each question carries 7 marks)

6. Discuss the major contributions of pioneers in scientific management.
7. Explain the project formulation stage of a construction project.
8. Discuss MIS effectiveness and efficiency criteria. Also, mention the failures of MIS.
9. Distinguish between break-even analysis and benefit cost analysis.
10. Explain long-term and short-term financing problems.
11. Explain commercial risk in PPP projects. Discuss the measures that can be adopted to mitigate the commercial risk.
12. With an illustration, explain the typical structure of a BOT project.

Syllabus

Module 1

Scientific Management: Concept - elements - contributions of pioneers in scientific management - basic principles of management with reference to construction industry - Construction Projects – concepts – types – life cycle of a construction project

Module 2

Management information Systems: Definition - evolution - organizational theory - systems approach - computer systems -database management - information systems for decision making - MIS effectiveness and efficiency criteria -failure of MIS.

Module 3

Engineering Economics: Definition and scope - cash flow - interest formulas and application - time value of money -bases of comparison - decision making amongst alternatives - rate of return - benefit cost analysis-incremental analysis replacement analysis - break even analysis.

Module 4

Capital budgeting - working capital management - construction accounting - long term and short term financing - problems and case studies.

Module 5

Private sector participation in Infrastructure Development Projects - PPP models - operation-maintenance, lease, concession (BOT), Private Finance Initiative - Risk identification and allocation in PPP projects - PPP structure and financing

Course Plan

No	Topic	No. of Lectures
1	**MODULE I (8 hours)**	
1.1	Scientific managementconcept - elements	1
1.2	Contributions of pioneers in scientific management	2
1.3	Basic principles of management with reference to construction industry	2
1.4	Construction Projects – concepts – types	1
1.5	Life cycle of a construction project	2
2	**MODULE II (8 hours)**	
2.1	Management information Systems Definition	1
2.2	Evolution - organizational theory	2
2.3	Systems approach -computer systems-database management	2
2.4	Information systems fordecision making	1
2.5	MIS effectiveness and efficiency criteria- Failure ofMIS.	2
3	**MODULE III (10 hours)**	
3.1	Engineering Economics- Definition and scope - Cash flow	2

3.2	Interest formulas and application- Time value of money	2
3.3	Bases of comparison -Decision making amongst alternatives - rate of return	2
3.4	Benefit cost analysis -Incremental analysis	2
3.5	Replacement analysis - break even analysis	2
4	**MODULE IV (6 hours)**	
4.1	Capital budgeting – workingcapital management- construction accounting	2
4.2	Long-term and short-term financing	2
4.3	Problems and case studies	2
5	**MODULE V (8 hours)**	
5.1	Private sector participation in Infrastructure Development Projects – concept, benefits, limitations	1
5.2	PPP models - operation-maintenance, lease, concession, Private Finance Initiative	4
5.3	Risk identification and allocation in PPP projects	1
5.4	PPP structure and financing	2

Reference Books

1. Kumar Neeraj Jha (2015). Construction Project Management Theory & Practice, Pearson India Education Services Pvt. Ltd.
2. Leland Blank and Anthony Tarquin (2017). Engineering Economy, McGraw-Hill Education, New York.
3. Frederick E. Gould (2013). Managing the Construction Process: Estimating, Scheduling, and Project Control, Pearson.
4. Joy P.K. (1994). Total Project Management - The Indian Context, New Delhi, Macmillan India Ltd.
5. Prasanna Chandra (2014). Projects – Planning, Analysis, Selection, Implementation Review, McGraw Hill Publishing Company Ltd., New Delhi
6. K. K. Chitkara (1998). Construction Project Management Planning Scheduling & Controlling, Tata McGraw Hill, New Delhi
7. A Guidebook on Public-Private Partnership in Infrastructure, UNESCAP (2011).
8. DinkarPagare. "Principles of Management" - Sultan Chand &Sons,New Delhi.
9. Robert G.Murdick, Joel E Ross, James R Clagget. "Information systems for ModernManagement "- PHI Learning Private Limited, New Delhi.
10. R.Paneerselvam. "Engineering Economics" - PHI Learning Private Limited, New Delhi.
11. B. L. Gupta and Amit Gupta. "Construction management and machinery" – Standardpublishers Distributors, Delhi.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221ECE009	CONSTRUCTION CONTRACTS METHODS AND EQUIPMENT	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: The course provides the basic understanding of the definition,types, elements and characteristics of contract as per Indian contract act. Students are also introduced to the laws related to dispute management, insurance and bonds as part of the project management. The course covers the construction methods and also the latest equipments used for the successful completion of modern construction projects.

Course Outcomes: After the completion of the course on Construction Contracts Methods and Equipment the student will be able to

CO 1	Describe the basic elements, types and conditions of contract.
CO 2	Explain the various steps involved in the contact documentation, claims and methods for dispute management.
CO 3	Summarise the laws related to insurance, bonds,specifications and termination of contract.
CO 4	Explain the modern construction methods, and their applications in the construction industry.
CO 5	Summarise the various types of equipment used in the construction projects andtheir capabilities.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1			2				
CO 2			2	1			
CO 3			2				
CO 4			2	1			
CO 5			2				

(1- Weak, 2-Medium, 3- strong)

Assessment Pattern

Bloom's Category	End Semester Examination
Remember	25
Understand	35
Apply	
Analyse	
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question(such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20%over the average ESE mark % for the core courses. ESE marks awarded to astudent for each elective course shall be normalized accordingly. For example, if theaverage end semester mark % for a core course is 40, then the maximum eligiblemark % for an elective course is 40+20 = 60 %.

Model Question Paper

QP CODE: **Reg No. :_____**

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIRST SEMESTER M.TECH.DEGREE EXAMINATION, MONTH & YEAR

Course Code: 221ECE009

CONSTRUCTION CONTRACTS METHODS AND EQUIPMENT

Max. Marks: 60 Duration: 2.5 hours

PART A

(Answer **ALL** questions; each question carries 5 marks)

1. Explain the term 'Competency of Parties' as per Indian Contract Act.
2. State and explain the various duties assigned to an arbitrator.
3. What are the different ways by which a contract can be discharged?
4. Differentiate between 3D volumetric and tunnel form of construction.
5. Explain the operating principle of a clam shell with a neat sketch.

PART B

(Answer **anyFIVE** questions; each question carries 7 marks)

6. "All agreements are not contracts." Explain this statement as per Indian Contract Act.
7. Write notes on appointment and removal of arbitrators as per arbitration act.
8. State and explain the laws related to workmen's compensation act.
9. Explain in detail the types of specifications and standards used in construction projects.
10. Elucidate the various methods used for soil stabilisation.
11. Summarise the several types of cost-effective construction methods.
12. List the different compaction equipments with neat sketches. Briefly describe thesuitability of each equipment.

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Syllabus

Module I

Contracts

Requirement of Contract, Elements of Contracts based on Indian Contract Act (1872), Types of Contracts based on Stakeholder responsibilities, Project Delivery Models – (Turnkey, EPC and PPP Models), Standard forms of contract - (FIDIC, NHAI and CPWD), General conditions of the contract for construction.

Module 2

Contract Administration

Project Documentation, Submission and approval of documents, Permits and approvals, Construction claims and disputes, Potential major claim areas, The Bid Proposal Process and the Potential for Disputes, Modes of resolving disputes, Understanding of Arbitration and Conciliation Act 1996 with latest amendments.

Module 3

Contract Management

Discharge of contract, Breach of contract, Tendering issues, Risks in construction contract, Regulatory aspects and ethics, Intellectual property act, Law of Torts, General Construction specifications, Commercial Construction Specifications, Bonds, Types of Bonds, Insurance, Workers compensation Insurance, Commercial general liability insurance, Builders riskinsurance.

Module 4

Construction Methods

Horizontal Systems – Hand - set slab forms, Table forms, Vertical Systems – Wall forms, Column forms, Combined Horizontal and Vertical Systems – Tunnel Form Systems, TrenchSafety. Cost effective construction methods - Prestressed concrete construction - 3D printing. Precast Flat Panel System-3D Volumetric Construction-Flat Slabs-Hybrid Concrete Construction-Precast Foundations-Insulating Concrete Formwork-Soil stabilisation methods

Module 5

Construction Equipment

Dozers and graders, Scrapers, hydraulic excavators, Draglines and Clamshells.
Concreting equipment - Crushers – feeders – screening equipment – batching and mixing equipment – hauling, pouring and pumping equipment – transporters. Equipment for compaction- Pneumatic Tired Rollers, Impact Compactors, Compaction Wheels, Intelligent compaction. Trucks and Hauling Equipments - Capacities of Trucks and Hauling Equipment – Calculation of truck productivity.

Course Plan

No	Topic	No. of Lectures
1	**Contracts(9)**	
1.1	Requirements of Contract	1
1.2	Elements of Contract based on ICA	1
1.3	Types of contracts based on stakeholder responsibilities	1
1.4	Project delivery models - Turnkey model, EPC model, PPP model	3
1.5	Standard forms of contract – FIDIC, NHAI, CPWD	2
1.6	General conditions of the contract for construction	1
2	**Contract Administration (7)**	
2.1	Project Documentation, Submission and approval of documents	2
2.2	Permits and approvals, Construction claims and disputes	1
2.3	Potential major claim areas	1
2.4	The Bid Proposal Process and the Potential for Disputes, Modes of resolving disputes	2
2.5	Understanding of Arbitration and Conciliation Act 1996 with latest amendments	1
3	**Contract Management (7)**	
3.1	Discharge of contract, Breach of contract, Tendering issues	1
3.2	Risks in construction contract, Regulatory aspects and ethics, Intellectual property act, Law of Torts	1
3.3	General Construction Specifications, Commercial Construction Specifications	1
3.4	Bonds, Types of Bonds	1
3.5	Insurance, Workers compensation Insurance, Commercial general liability insurance, Builders risk insurance	3
4	**Construction Methods (9)**	
4.1	Horizontal systems-Hand-Set slab form, Table forms, Vertical Systems-Column form-Wall forms	2
4.2	Combined Horizontal and vertical Systems-Tunnel form systems, Trench safety	2
4.3	Cost effective Construction Methods-Prestressed Concrete Construction-3 D Printing	2
4.4	Precast Flat Panel System-3D Volumetric, Flat Slab, Hybrid Concrete Construction	1
4.5	Precast Foundations, Insulating Concrete Formwork	1
4.6	Soil Stabilization Methods	1
5	**Construction Equipment (8)**	
5.1	Dozers and graders, Scrapers, hydraulic excavators, Draglines and Clamshells	2
5.2	Concreting equipment - Crushers – feeders – screening equipment – batching and mixing equipment – hauling, pouring and pumping	2

	equipment – transporters	
5.3	Equipment for compaction- Pneumatic Tired Rollers, Impact Compactors, Compaction Wheels, Intelligent compaction	2
5.4	Trucks and Hauling Equipment - Capacities of Trucks and Hauling Equipment – Calculation of truck productivity	2

Reference Books

1. Indian Contract Act (1872)
2. Sidney M. Levy –"Project Management in Construction, 7th Edition", 2018 McGraw-HillEducation.
3. Richard Lambeck and John Eschemuller- "Urban Construction Project Management",2009 The McGraw-Hill Companies, Inc.
4. Donald L. Marston, J.D., P.Eng "Law for Professional Engineers: Canadian and GlobalInsights", 5th Edition.
5. David A. Madsen "Commercial Building Construction: Materials and Methods", 1st Edition.
6. Clifford J. Schexnayder, Christine M. Fiori, "Handbook for Building Construction:Administration, Materials, Systems, and Safety", 1st Edition, 2021 McGraw Hill.
7. Construction Planning, Equipment, and Methods, 9th Edition, 2018 McGraw-Hill Education
8. Robert L. Peurifoy, P.E., Clifford J. Schexnayder, P.E., Ph.D., Robert L. Schmitt, P.E., Ph.D.Aviad Shapira, D.Sc.
9. Dr. Mahesh Varma, "Construction Equipment and its Planning and Application ", Metropolitan Book Company, New Delhi
10. Mustafa Mahamid , Edwin H. Gaylord , Charles N. Gaylord, "Structural EngineeringHandbook", 5th edition.
11. Hwaiyu Geng, "Manufacturing Engineering Handbook", 2nd edition.
12. Richard L. Handy, "Foundation engineering: Geotechnical principles and practical applications", 1st edition.